APPENDIX B
DESIGN CALCULATIONS

1.0 INTRODUCTION

This appendix presents a description of the general types of calculations that may be required for AOP applications. Based on the specific type of AOP technology selected and specific types of equipment and accessories used, additional calculations may be required. Although the calculations described refer primarily to UV/H_2O_2 applications, several of these calculations should be used in conjunction with other calculations that are required in the development of the design for the entire treatment process or treatment facility. Design examples illustrating the use of several of these calculations are presented in Appendix E.

2.0 PURPOSE

The primary purpose of the AOP design calculations is to provide design criteria for sizing equipment for editing guide specifications and developing construction drawings. Based on the preliminary selection of equipment, additional calculations can also be performed to determine parameters such as utility requirements and supporting mechanical and electrical distribution systems.

3.0 DESIGN BASIS AND DATA SOURCES

Several types of data sources can be used for the basis of the design calculations. Typical sources of data include pre-engineering design reports and treatability studies, standard reference materials, and other sources such as telephone conversations. Any source of data or basis used for the design calculations should be identified and referenced appropriately in the design analysis.

3.1 PRE-ENGINEERING DESIGN AND TREATABILITY STUDIES

Pre-engineering design reports and treatability studies (i.e., laboratory, bench-scale and/or pilot-scale testing) are typically used as the basis of the design calculations. Before the AOP design calculations are performed, the specific parameters should be identified, if possible, from these sources.

Each data source used should be clearly identified within the design calculation and properly referenced with the date, title, or other pertinent information that will identify the data source and its validity.

3.2 REFERENCE MATERIALS

Data and information from reference materials, other than data from pre-engineering design and treatability studies, can also be also used for AOP design calculations. Reference materials consist of applicable codes, standards, textbooks, standard tables, and manufacturers* catalogs and examples of manufacturers* literature. Each reference source used should be properly referenced with the date, title, issue, or other pertinent information to assure complete identification.

3.3 TELEPHONE CONVERSATION RECORDS

In addition to reference and design data from the design analysis report, telephone conversations with equipment suppliers and manufacturers and regulatory agencies may also be used for the design calculations. A record should be maintained including date, person talked to and short summary of the conversation.

4.0 COMPOSITION AND CONCENTRATION DEPENDENT CALCULATIONS

Composition- and concentration-dependent calculations are performed to provide the design basis for sizing the AOP equipment and for related operation requirements. These types of calculations can be categorized as pretreatment calculations and process calculations.

4.1 PRETREATMENT CALCULATIONS

Pretreatment calculations include those required to provide the initial basis for sizing equipment and process conditions such as mass balance calculations and determination of the required AOP capacity.

4.1.1 Mass Balance Calculations

The mass balance calculations should be performed based on previously determined hydraulic flow rates and contaminant concentrations for each stream to determine the total mass flow

rate of contaminants to be treated. These calculations are based on the mass balance equation:

Mass Out = Mass In

The “mass out” term refers to the total TOC or specific target compound(s) to be removed by AOP. This term is determined from the “mass in” term that is determined by the summation of mass flow rates from each stage as determined by multiplying flow rates by contaminant concentration from each unit. To aid in these calculations, a flow schematic showing both hydraulic flow rates, solid concentrations, and mass flow rates to and from each process unit should be developed.

Based on the calculations of total mass of contaminant generated on a daily basis, other process calculations can be performed to determine the capacity of the AOP, oxidant dosage, chemical feed systems, and other accessories.

4.2 PROCESS CALCULATIONS

Process calculations include those related to the determination of design criteria and sizing of storage containers, chemical feed systems, and accessories.

4.2.1 Storage Calculations

Several types of storage containers may be required for AOP applications including:

- equalization tanks for storage of influent wastewater if flow fluctuations occur;
- effluent holding tank for quality checks of the treated water prior to discharge;
- hydrogen peroxide storage tank, and
- other chemical storage tanks, if applicable.

4.2.2 Chemical Feed Systems

Chemical feed systems may include tanks and pumps for pH adjustment, hydrogen peroxide feed, and catalysts feed system. The calculations of the chemical dosage per day will be based on

the influent wastewater flow rates, contaminant concentrations, and the chemical dose required to adjust pH to a desired level.

5.0 SUPPORT UTILITY REQUIREMENTS

Based on the initial selection of equipment, utility requirements for ventilation, power, water, air, telephone, and other utilities can be calculated. Although some of these calculations may be determined as requirements for the entire treatment facility, incremental calculations may be required that apply specifically to equipment or facilities required for filter-press applications.

5.1 SPECIAL VENTILATION SYSTEMS

Typically, ventilation calculations are performed with heating ventilation and air conditioning calculations for the entire treatment facility and are not specifically performed for the AOP application. Under normal conditions, as described in Subsection 10.3.3 of Appendix A, the minimum ventilation rate of six air changes per hour for summer ventilation and three air changes per hour for winter ventilation should be applied. However under specific applications, such as those in areas where dust is possible, additional ventilation requirements and calculations may be required.

5.2 POWER REQUIREMENTS

Several types of calculations for power requirements can be used in the design of an AOP application including a normal load and lead protection analysis, a ground fault current analysis, and lighting analysis. These types of calculations are usually performed as part of the electrical calculations provided for the entire treatment facility. Because these types of calculations are application and equipment-specific only, a description of these types of calculations follows.

The normal load and load protection analysis consists of the determination of electrical load requirements for the AOP and associated components such as pumps and controls, air compressor, air cooler/chiller for the cooling system and ozone thermal destruction unit(s), if applied. Once the load analysis is performed, a load protection analysis is then performed to ensure the proper design and placement of circuit transformers for the

overcurrent protection of individual component from its power source. The ground fault current analysis is also performed to determine the rated listing for individual components.

In addition to direct power requirements, lighting calculations are typically provided with power requirement calculations. However, the lighting calculations and associated requirements are typically provided with the entire treatment facility*s general lighting calculations, unless special light requirements for platforms, mezzanines, or catwalks are required.

5.3 WATER REQUIREMENTS

Water requirements for AOP applications include water required for cooling of the reactor and/or ozonator, fire protection and potable water. Water requirements for cooling are determined by calculations required for the reactor and/or ozonator. Water requirements for fire protection are typically determined by calculations required for the entire treatment facility. Potable water requirements are based on frequency, duration, and quantity required for each specific system within the AOP application. Systems that typically require potable water include: dilution water for chemical preparation, dilution water for lamp acid wash, emergency shower and eye wash. Based on the specific requirements for each of these applications, calculations will be performed for the quantity of potable water required and associated distribution systems.

5.4 AIR REQUIREMENTS

In general, calculations for air requirements are based on the frequency, duration, quality, and pressure of air required to perform several functions with AOP applications. Typically, two types of air quality are required for AOP application: instrument air and plant air. The instrument air is typically passed through an air cooler and air dryer to produce a dry quality air required for pneumatically operated controls. Although two types of air are required, only one air compressor system is typically required to distribute the air requirements to supporting systems. Therefore calculations that are performed for the air system include those for sizing the air compressors and those for sizing air distributions systems.

The air compressor system is of typical size based on the calculations of the sum of the air requirements and the highest pressure required. The air is then distributed to the air distribution system by pressure regulators. Additional calculations performed for the distribution systems include those required for sizing storage receivers, air dryers, and distribution piping system. These calculations are primarily based on the specific air requirements for each individual demand.

High quality air is also required for the process gas of the ozonator (if air is used to generate ozone) . Because the specific calculations are equipment specific, only a description of calculations that may be required are presented in this appendix.

5.5 TELEPHONE LINE REQUIREMENTS

A telephone connection or cellular telephone is required to order supplies, contact emergency services, and provide normal communications. The specific requirements are typically determined for the site conditions and specific control outputs requiring remote alarms and specified within the guide specification interfacing with other controls requiring remote alarms within the treatment facility.

6.0 ADDITIONAL REQUIREMENTS

In addition to the process, mechanical and electrical calculations, additional design requirements and calculations that may be required for AOP applications include those related to architectural requirements such as the determination of aisle space, equipment clearances, and storage space; structural requirements for the AOP treatment units, supporting accessories, and chemical storage; operation and maintenance provisions; and health and safety requirements. However, these types of calculations are application specific, and, therefore, no specific calculations are provided in this appendix.